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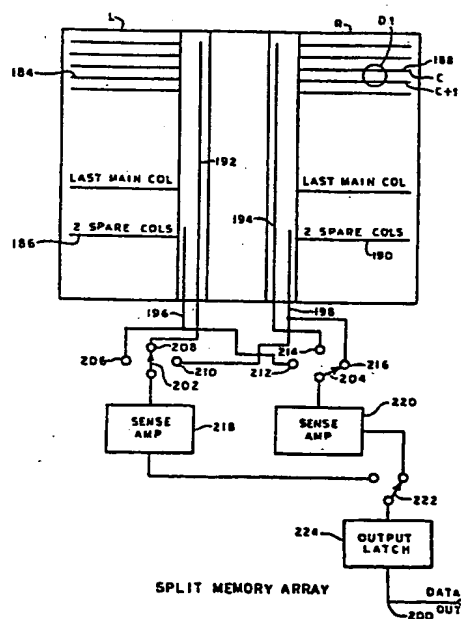
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(54) Redundancy scheme for a dynamic memory.

(57) A redundancy scheme for a dynamic memory is arranged to replace defective main memory cells with spare memory cells. The memory array is divided into first and second sectors (L, R), the first sector (L) containing a portion (184) of each main memory column and one or more spare columns (186), and the second sector (R) containing the remaining portion (188) of each main memory column and one or more spare columns (190). Means (192, 194, 196, 198) are provided for accessing the main memory columns and the spare memory columns such that, when a portion (184) of an addressed main column in said first sector (L) is defective and its remaining portion (188) in said second sector (R) is not defective, the non-defective portion (188) of said addressed column is accessed and a spare replacement column (186, 190) in one of said sectors (L, R) is accessed in place of the defective portion of the addressed column. Means (218, 220, 222) are provided for coupling the data associated with the accessed portion of the addressed column and the replacement spare column to a data output (200).



REDUNDANCY SCHEME FOR A DYNAMIC MEMORY

5 The present invention relates generally to MOS (metal oxide semiconductor) memories, and is particularly directed to a redundancy scheme for use in such a memory.

10 MOS memories generally include a memory array in the form of rows and columns of main memory cells for storing digital data. In a typical memory, there are thousands of individual memory cells, each of which must function properly. A single inoperative memory cell destroys the usefulness of the memory and, therefore, lowers the yield of the wafer on which many memories are simultaneously manufactured.

15 To increase the yield of each wafer, it has been proposed to include spare memory cells in each chip. Thus, if a main memory cell is found to be defective during testing by the manufacturer, a spare memory cell is selected to replace the defective memory cell.

20 Some prior schemes for selecting spare memory cells include a single spare column of cells for replacing a main column of cells in which a defective cell is located. Although such schemes evidently perform their limited function, they are incapable of "fixing" larger defects in the memory which may render inoperative one or more columns (or rows) of main cells.

25 Prior redundancy schemes also suffer from other disadvantages. For example, some are implemented in a manner that causes an undesirably large amount of standby power to be dissipated. In addition, relatively complex circuitry has usually been required to implement the redundancy scheme, and the access time of the memory has been impaired. For these and other reasons, prior redundancy schemes have not been entirely satisfactory.

35 It is an object of the invention to provide a

redundancy scheme for a RAM.

According to the present invention there is provided a RAM having columns of main memory cells a plurality of spare memory cells, a main decoder for accessing the main memory cells, and a spare decoder for accessing the spare memory cells, and a redundancy scheme for replacing defective main cells with spare cells, characterised in that the redundancy scheme is arranged to replace defective main cells with spare cells without disabling the main decoder, and in that said RAM comprises

a memory array divided into first and second sectors, the first sector containing a portion of each main memory column and one or more spare columns, and the second sector containing the remaining portion of each main memory column and one or more spare columns, means for accessing the main memory columns and the spare memory columns such that, when a portion of an addressed main column in said first sector is defective and its remaining portion in said second sector is not defective, the non-defective portion of said addressed column is accessed and a spare replacement column in one of said sectors is accessed in place of the defective portion of the addressed column; and means for coupling the data associated with the accessed portion of the addressed column and the replacement spare column to a data output.

- 30 An embodiment of a redundancy scheme of the invention has the advantage that it is capable of repairing

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relatively large defects in the memory.

5 An embodiment of a redundancy scheme of the invention has the advantage that it dissipates little or no standby power, that it is relatively simple in construction, and that it does not substantially impair the memory's access time.

Embodiments of the present invention will hereinafter be described, by way of example, with reference to the accompanying drawings, in which:

10 Figure 1 illustrates, in a general manner, the architecture of a RAM employing a redundancy scheme;

Figure 2 is a block diagram of an address buffer and its associated fuse and comparison circuitry for use in the RAM of Figure 1;

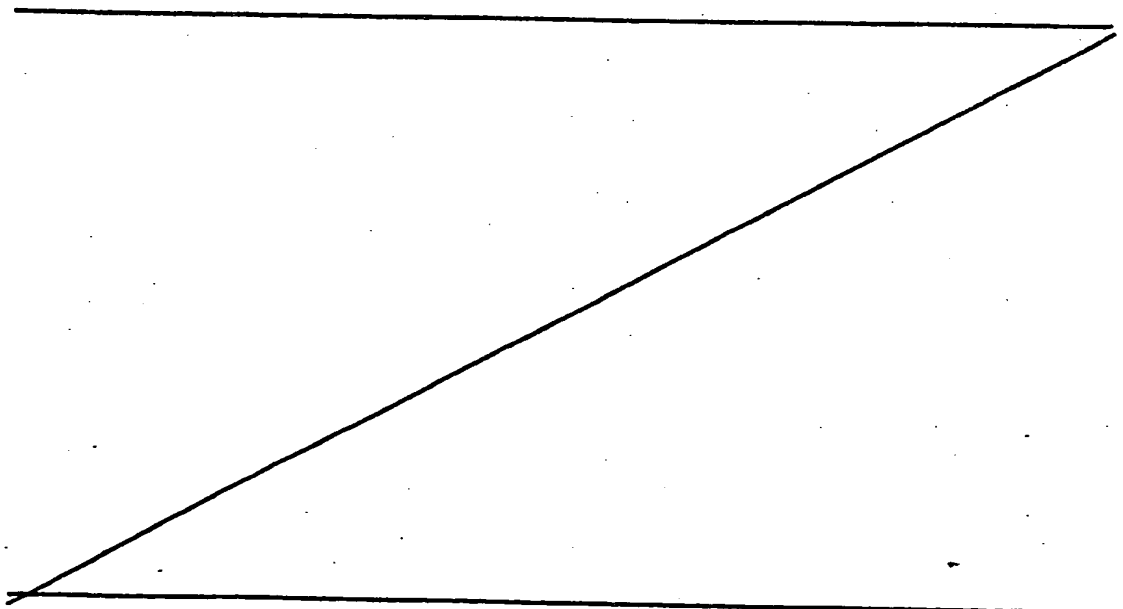
Figure 3 is a detailed circuit diagram of the fuse and compare circuitry of Figure 2;

Figure 4 shows waveforms of clock signals input to the circuitry of Figure 3;

20 Figure 5 shows details of the disabling circuitry of Figure 1;

Figure 6 depicts waveforms of clock signals which are input to the disabling circuitry;

Figure 7 shows an exemplary decoder for use



in the RAM:

Figure 8 shows waveforms of clock signals which are inputs to the circuitry shown in Figures 7 and 9;

Figure 9 shows an exemplary spare decoder for use in the RAM;

Figure 10 is a simplified rendering of the RAM's architecture to illustrate how a large defect may be repaired; and

Figure 11 shows an alternate accessing scheme for use with a split memory array having half the number of spare columns as the RAM of Figure 1.

The redundancy scheme herein is described as part of a 64K dynamic RAM (random access memory). To illustrate how the redundancy scheme interfaces with the RAM, reference is made to Figure 1 which shows the architecture of the RAM's chip.

The RAM's memory includes 256 rows by 256 columns of cells and is divided into eight main arrays or octants 10, 12, 14, 16, 18, 20, 22 and 24. Each of the latter arrays includes 64 columns by 128 rows of memory cells. To access a particular cell, one bit of row address information is received at each of the eight input pins A0-A7. The row information received at pins A0-A5 is applied to a block 30 entitled "address buffers and fuse compare circuits". Ignoring the "fuse" function for the moment, the block 30 buffers the address inputs, and for each address input, develops true and complementary address outputs  $A_1$  and  $\overline{A_1}$  which are used to drive row decoders 32. These decoders operate to select a group of four rows of cells from the memory.

To identify the one row which the 8 bits of address information uniquely identifies, the bits received

at pins A6 and A7 are coupled to select circuitry 34. The latter circuitry typically selects one of the rows associated with one of the four previously selected rows. Sense amplifiers 35 and 35a amplify and couple the data associated with the selected row to a data output (not shown).

To select a particular column of memory cells, the input pins A0-A7 then receive an 8 bit column address word. The uniquely identified column is then accessed in the manner described above except that column decoders 36 are employed rather than the row decoders 32.

To effect redundancy, the illustrated RAM includes 16 spare rows of memory cells and 4 spare columns of memory cells. The spare rows are shown as 4 groups 38, 40, 42 and 44 of spare rows, each such group including four rows. The spare columns are shown as two groups 46 and 48 of spare columns, each such group including two columns. As described in more detail below, each of the spare groups of rows may replace four main rows of cells in the memory, as defined by A0-A5, and each of the spare groups of columns may replace any two main columns of cells in memory.

To effect substitution of either a group of spare rows or a group of spare columns, the RAM includes fuse circuitry in the block 30 for retaining addresses of defective main rows and columns of cells, decoder disable circuitry 50, spare row decoders (SRD) 52, 54, 56 and 58, and spare column decoders (SCD) 60 and 62. Generally speaking, the fuse circuitry in the block 30 is programmed during probe testing with addresses of defective cells and operates such that, when the input pins A0-A5 receive an address previously found to be that of a defective cell, spare select signals  $SI_1$  and  $SI_2$  are generated for enabling the spare row decoders

52-58 and the spare column decoders 60 and 62. If, for example, the inputs at pins A0-A5 receive row address information which the fuse circuitry in the block 30 identifies as the address of a defective row or rows in memory array 10, the spare row decoder 52 accesses the four spare rows 38. In addition, the decoder disable circuits 50 force the signals  $A_i$  and  $\overline{A_i}$  high to inhibit the row decoders 32 from accessing the memory array 10. Likewise, if the information at pins A0-A5 is determined by the block 30 to be an address of a defective column or columns in the memory array 10, the signal  $SI_1$  enables the spare column decoder 60 for accessing the spare column 46. In addition, the decoder disable circuits 50 disable the main column decoders 36.

In the embodiment described herein, the groups 38 and 40 of spare rows can each replace 4 rows in any of the memory arrays 10, 12, 14 or 16. The groups 42 and 44 of spare rows can each replace four rows in any of the memory arrays 18, 20, 22 and 24. The groups 46 and 48 of spare columns can replace four main columns anywhere on the chip.

Referring now to Figure 2, a functional block diagram is shown of one of the six address buffers and its associated fuse circuitry included in the box 30 of Figure 1. The address buffer 64 may be of conventional construction for receiving an input address bit  $A_{in1}$  and a reference voltage  $V_{ref}$ . If  $A_{in1}$  is greater than  $V_{ref}$ , the input is considered to be a logical "one", the output  $A_i$  on lead 66 goes high, and the output  $\overline{A_i}$  on lead 68 remains low. Conversely, if  $A_{in1}$  is less than  $V_{ref}$ , the input is considered to be a logical "zero",  $\overline{A_i}$  goes high, and  $A_i$  remains low. The signals on the leads 66 and 68 are applied as inputs to the row decoders 32 and the column decoders 36.

Associated with the buffer 64 is a store for a defective row address comprising a pair of row fuse

circuits 70 and 72, and a store for a defective column address comprising a pair of column fuse circuits 74 and 76. Referring first to the row fuse circuit 70, it receives an input identified as  $ECR_1$  and a row select clock input identified as  $\phi_{RS}$ . During probe testing, an automatic memory tester senses the operability of all cells in the memory. When a defective cell is found, a high level signal  $ECR_1$  is applied to an internal pad on the chip for application to the row fuse circuit 70 and to other similar row fuse circuits located in the block 30 (Figure 1). As described in more detail hereinafter, the row fuse circuit 70 blows an internal fuse for storing the address of the defective cell.

The column fuse circuit 74 is similar to the row fuse circuit 70 except that it receives (during probe test) a signal identified as  $ECC_1$  for storing the address of a column having a defective memory cell. The column fuse circuitry 74 is clocked by a column select signal identified as  $\phi_{CS}$ .

The row fuse circuit 72 and the column fuse circuit 76 are similar, respectively to circuits 70 and 74, except that the former receive probe test inputs identified as  $ECR_2$  and  $ECC_2$ . With this arrangement, the row fuse circuit 70 may store one bit of an address of a defective row anywhere on the chip. Likewise, the row fuse circuit 72 may store another bit of an address of a defective row anywhere on the chip. The other five buffers and fuse circuits in the block 30 store the remainder of the address. Likewise, the column fuse circuits 74 and 76 each store a bit of an address of a defective column anywhere on the chip.

When the chip is in normal operation, i.e., after probe testing, the address stored in the fuse circuitry



is compared with incoming row and column addresses. If a stored address is the same as an incoming address, a spare column and/or row is substituted for the defective column or row. To effect such comparison, the output of the row fuse circuitry 70 is coupled via switches S1 and S2 to the inputs of a comparator comprising gates 78, 80 and 82. The gates 78 and 80 also receive as inputs the incoming buffered addresses  $A_i$  and  $\overline{A_i}$  for comparison with the output of the fuse circuitry 70 and 74. The gates 78, 80 and 82 act essentially as an exclusive OR circuit such that, when the inputs  $A_i$  and  $\overline{A_i}$  match the address stored in the row fuse circuitry 70, the spare inhibit output  $SI_1$  on lead 84 remains at a low level. If no such match occurs, the output  $SI_1$  is pulled high.

A simultaneous comparison occurs between the buffered inputs  $A_i$  and  $\overline{A_i}$  and the outputs of row fuse circuit 72. The latter's outputs are coupled via switches S3 and S4 to another exclusive OR type comparator comprising gates 86, 88 and 90. The gates 86 and 88 also receive the signals  $A_i$  and  $\overline{A_i}$ . If a match occurs between the signals  $A_i$  and  $\overline{A_i}$  and the output of the row fuse circuitry 72, a spare input output  $SI_2$  at lead 92 remains low. If no match occurs  $SI_2$  is pulled high.

It should be understood that, because the spare columns can replace defective main columns anywhere on the chip, either of the signals  $ECC_1$  and  $ECC_2$  may go high to select a particular group of columns to be replaced by spare columns. The automatic memory tester may, for example, drive the signal  $ECC_1$  high on locating a first defective cell and then drive the signal  $ECC_2$  high on locating a defective cell in another column. The reverse sequence may also be used. It should be understood also that the lead 84 is wire ORed to corresponding outputs of similar fuse circuitry associated with the other five address buffers in the block 30. Thus, if any one bit

of an incoming row address does not match with a programmed fuse address, the line carrying the ORed spare inhibit signals  $SI_1$  will be pulled high. This in turn will cause a spare row to be left unselected. If, however, all bits of the incoming address match the address programmed in the fuse circuitry, the line carrying the spare inhibit signal will remain low and a spare row will be selected.

The spare inhibit  $SI_2$  is also wire ORed to similar output of fuse circuitry associated with the other five address buffers.

When a column address input is received, the switches (which may be logic operated transistors) are thrown to their other positions for comparing the buffered address inputs with addresses programmed or stored in the column fuse circuits 74 and 76. If all bits of an incoming column address match the programmed addresses of a defective column, the line carrying the ORed  $SI_1$  (or  $SI_2$ ) inhibit signals remains at a low level. If no such match occurs, that line is pulled high.

With the arrangement shown in Figure 2, two programmable addresses (both row and column) are provided for maximum flexibility in correcting defects.

With the two row fuses and the two column fuses, any two arbitrary groups of four rows and two columns can be replaced. If, for example, a defect crosses an address boundary, i.e., the defective rows or columns are identified by different addresses, the memory can still be repaired since any two arbitrary groups can be replaced.

Another advantage of the illustrated arrangement is that column address inputs and row address inputs time share a single buffer and the same comparison

circuitry. Hence, a reduction in circuit complexity is provided.

A reduction in the number of fuses required in the embodiment of Figure 2 may be effected by replacing the second row and column fuse circuits 72 and 76 with A+1 comparators, where A indicates the address of a defective cell stored in fuse circuits 70 or 74. For example, if the row fuse circuit 70 is associated with cell address 000000 and its fuse is blown, it may output a signal to an A+1 generator (which replaces row fuse circuit 72) for developing output signals indicative of a defective cell at address 000001. In this manner, the number of fuses required can be halved. While only adjacent groups of cells can be fixed in this manner, the ability to correct defects on address boundaries is maintained.

Referring now to Figure 3, a circuit diagram is shown for the row fuse circuit 70, the column fuse circuit 74, and their common comparator. The row fuse circuit 72, the column fuse circuit 76, and their comparator may be similarly constructed.

The row fuse circuit 70 is similar to the column fuse circuit 74. Hence, a description will only be given of the operation of the circuit 70, it being understood that the column fuse circuit 74 operates in a similar manner. As shown, the circuit 70 includes a fuse F1 which may be made of polysilicon material and which is blown during probe testing to store information indicative of the address of a defective cell. To blow the fuse F1, the circuit 70 includes transistors 94 and 98, the drain of the latter transistor being coupled to a node 100 and to the fuse F1 for carrying fuse blowing current from  $V_{cc}$ , through the fuse F1, and to ground when the transistor 98 is turned on. Assuming that an automatic testing machine has located a defective cell in a row associated with the

circuitry 70, a high level signal identified as  $ECR_1$  will be applied to the gate of the transistor 94 when the address input  $A_i$  is also driven high. Consequently, the transistor 94 conducts to turn on the transistor 98, thereby providing a path for fuse blowing current through the fuse F1 and to ground through the transistor 98.

A transistor 99 is coupled to the gate of the transistor 98 to hold the voltage there at a low level except when the signals  $A_i$  and  $ECR_1$  are high.

Referring briefly to Figure 4, waveforms are shown of four clock signals  $\phi_{AS}$ ,  $\phi_{AR}$ ,  $\phi_{RS}$  and  $\phi_{CS}$  which are applied to the fuse circuits 70 and 74 during normal operation of the memory.

Returning again to Figure 3, it will first be assumed that the fuse F1 has not been blown during probe testing. The signal  $\phi_{AR}$  is initially high, as shown in Figure 4, and is applied to transistors 102 and 104 in the circuit 70, and to a transistor 106 in the circuit 74. The sources of transistors 102 and 106 are coupled to lines identified as "fuse" and "fuse," respectively, so as to initially precharge both lines to a high level, such as four volts when  $V_{CC}$  is equal to 5 volts. A node 108, which is coupled to the transistor 104, is also pulled high.

The gate of a grounded source transistor 110 is coupled to the node 108, wherefore the latter transistor is turned on. When the signal  $\phi_{AS}$  goes high, another transistor 112, coupled to the drain of the transistor 110, is also turned on. Hence, the voltage at the drain of transistor 112 tries to fall, but it is held at a high level by the unblown impedance of the fuse F1.

The node 100 is also coupled to the gate of a transistor 114 whose source receives the signal  $\phi_{AR}$  and whose drain is coupled to the node 108. When the signal  $\phi_{AR}$  goes low (see Figure 4), the transistor 114 turns on to pull the voltage at node 108 low. The latter node is

coupled to the fuse line via another transistor 116 whose gate receives the signal  $\phi_{RS}$ . Because  $\phi_{RS}$  is at a high level, the transistor 116 is on for coupling the low level at node 108 to the fuse line.

5           The fuse line is coupled to a transistor 118 whose gate receives the signal  $\phi_{RS}$  and whose drain is coupled to the node 100. With  $\phi_{RS}$  high, the transistor 118 couples node 100 to the fuse line which remains high because of the high level at node 100. Thus, with the  
10 fuse F1 unblown, the fuse line is high and the fuse line is low.

          Considering the case in which the fuse F1 has been blown, the fuse and fuse lines are, of course, both initially precharged to high levels as described above  
15 when the signal  $\phi_{AR}$  is high. The signal  $\phi_{RS}$  is also high, thereby holding the transistor 118 on to pull the voltage at node 100 low. Because of the clock timing shown in Figure 4, the voltage at node 100 falls no later than the signal  $\phi_{AR}$  goes low. Consequently, the transistor 114  
20 remains off. The off condition of the transistor 114 allows the fuse line to remain at its precharged high level. However, the fuse line is pulled low because the transistor 118 couples the fuse line to the low potential of the node 100. Thus, when the fuse F1 is blown, the  
25 fuse line is low and the fuse line is high.

          To compare the fuse and fuse data with an incoming address from the buffer 64 (Figure 2), a comparator comprising transistors 120, 122 and 124 is coupled to the fuse and fuse lines at the gates of transistors 120 and 12  
30 The drains of the latter transistors receive the incoming address bits  $\bar{A}$  and A, respectively, from the address buffer. If the fuse F1 had been previously blown, the fuse line is low and the fuse line is high. Now if the input A is low and the input  $\bar{A}$  is high, the transistor 122 causes a node  
35 126 to be driven low. The low level signal at the node 12

is buffered to the output lead 128 to develop a low level spare inhibit signal ( $SI_1$ ). Consequently, a spare row decoder is enabled for accessing a spare row of memory cells. The transistor 124 receives the signal  $\phi_{AR}$  at its gate in order to start the node 126 at low level.

If there is no match between the address inputs A and  $\bar{A}$  on the one hand, and the fuse data on the other hand, suffice it to say that the spare inhibit signal  $SI_1$  is driven to a high level for inhibiting the selection of a spare row.

The fuse circuitry 74 operates in a manner similar to that described above with respect to the fuse circuitry 70 so that the spare inhibit signal  $SI_1$  is held low when an incoming column address matches the address information associated with the fuse F2.

One of the more significant aspects of Figure 3 is the circuitry comprising transistors 110, 112 and 114 and the manner in which they are clocked. With the illustrated arrangement, a very simple circuit is provided for generating fuse and fuse data with no continuous consumption of D.C. current. It also allows one end of the fuse  $F_1$  to be coupled to  $V_{cc}$  for ease of fusing in N channel logic.

The circuit also reliably senses the state of the fuse F1 even though the impedance of the fuse may change but from 100 ohms in an unblown state to 1000 ohms in its blown state. This effect is due to the fact that, because all the fuse current flows through transistors 110 and 112 when  $\phi_{AS}$  is high, those transistors may be sized to carry the required current to drop the potential at node 100 sufficiently for holding the transistor 114 off. Thus, even though the fuse may not blow completely, the illustrated circuit is made sensitive enough to detect a relatively small impedance change in the fuse F1.

Referring now to Figure 5, the decoder disabling circuitry 50 of Figure 1 is shown in more detail. The illustrated circuitry includes transistors 130 and 132 which receive the spare inhibit signal  $SI_1$  developed by the fuse and compare circuit of Figure 3. Another pair of transistors 134 and 136 receive another spare inhibit signal  $SI_2$  developed by additional fuse and compare circuitry which may be similar to that shown in Figure 3 except that it operates on different address inputs.

Coupled to the drains of transistors 130 and 134, respectively, are transistors 138 and 140 whose gates receive a precharge clock signal identified as  $\phi_p$ . The source of the transistor 138 is coupled to the gate of another transistor 142 which receives a clock signal identified as  $\phi_{AOR}$ . Likewise, the source of the transistor 140 is coupled to the gate of a transistor 144 which also receives the clock signal  $\phi_{AOR}$ .

Referring briefly to Figure 6, the clock signal  $\phi_p$  and  $\phi_{AOR}$  are shown, along with the clock address select  $\phi_{AS}$  to indicate the relative timing of the various clocks.

Returning to Figure 5, the drain of the transistor 132 is coupled to the gates of transistors 146 and 148 the sources of which are coupled to leads 150 and 152. These leads force the address data signals  $A_1$  and  $\overline{A_1}$  to both go high when a spare row or column is selected in order to disable the row and column decoders.

The drain of the transistor 136 is also coupled to the gates of a pair of transistors 154 and 156 whose sources are coupled to leads 150 and 152.

In operation, the transistors 138 and 140 are turned on by the signal  $\phi_p$  for initially precharging nodes 158 and 160 to high levels. If the signals  $SI_1$  and  $SI_2$  are both high (no match between an incoming address and an address of a defective cell), transistors 130 and 134 conduct to pull the voltages at nodes 158 and 160 low.

When the signal  $\phi_{AOR}$  goes high, the drains of transistors 132 and 136 (nodes 162 and 164) remain low. Hence, transistors 146, 148, 154 and 156 remain off and the state of the signals  $A_i$  and  $\overline{A_i}$  remains unaltered to prevent disabling the row and column decoders.

If the signal  $SI_1$  had remained low (a match had been sensed), the node 158 would have remained high and the node 162 would have been driven high when  $\phi_{AOR}$  came up. This would have turned transistors 146 and 148 on to drive the signals  $A_i$  and  $\overline{A_i}$  high. Consequently, the row and column decoders would be disabled.

Likewise, if the signal  $SI_2$  had remained low, transistors 154 and 156 would have been turned on for driving the signals  $A_i$  and  $\overline{A_i}$  high. Thus, any time a match is sensed between an incoming address and the address of a defective cell, both signals  $A_i$  and  $\overline{A_i}$  are driven high to disable the row and column decoders.

The main row and column decoders shown in Figure 1 and the spare row and column decoders may all be conventional. Figure 7 shows an exemplary decoder which may be used in the main row and column decoders, and Figure 9 shows an exemplary decoder which may be used in the spare row decoder and the spare column decoder. Figure 8 illustrates clock signals  $\phi_p$  and  $\phi_1$  which are input to the decoders in Figures 7 and 9.

Referring first to Figure 7, the decoder shown therein includes address input transistors 166a-166n, each of which receives one bit of an address input. Coupled to the drains of transistors 166a-166n is another transistor 168 whose gate receives the precharge clock signal  $\phi_p$ . Its source is coupled by a transistor 170 to the gate of an output transistor 172.

Initially, the transistor 168 is turned on by the signal  $\phi_p$ . Then, if all address inputs remain low, the high level voltage at the source of transistor 168 is



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coupled to the decoder's output for selecting main columns or rows of memory cells.

The spare decoder shown in Figure 9 includes a transistor 174 for receiving a spare inhibit signal  $SI_1$  (or  $SI_2$ ) at its gate, a transistor receiving the clock signal  $\phi_p$  at its gate, and transistors 178 and 180. The clock signal  $\phi_p$  turns on the transistor 176 for pre-charging the drain connection (node 182) of the transistor 174. If the signal  $SI_1$  then goes high, the node 182 and the spare decoder's output are pulled low to prevent selection of a spare row or column. If, however, the signal  $SI_1$  goes low, the decoder's output stays high for selecting a spare row or column.

Referring now to Figure 10, a simplified diagram of the RAM's architecture is shown to explain an alternate way of replacing defective columns of cells. In this figure, the memory is again shown as being divided into octants 10, 12, 14, 16, 18, 20, 22 and 24. The top half of the figure shows a pair of memory columns C which extend through quadrants 10, 14, 18 and 22. Another pair of columns C+1 is adjacent the column C, and a defect D is shown which covers adjacent columns.

The two spare columns 46 may be thought of as including portions 46a and 46b, and the two spare columns 48 may be thought of as including portions 48a and 48b. According to the redundancy scheme described thus far, the defect may be cured by substituting spare column portions 48a and 48b for the entirety of main column pairs C+1. In this method of substitution, the main decoders are disabled when spare columns 46 and 48 are selected in order to prohibit access to any portion of the main memory array.

According to another aspect of the invention, a split memory array is used wherein memory columns to the left of the decoders 36 may be accessed independently of the memory columns to the right of the decoders 36.

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Thus, the defect D may be repaired by replacing the defective portion of main column pairs C in octants 10 and 14 with spare columns portions 46a and by replacing that portion of the defective main column pairs C+1 in octants 10 and 14 with spare column portions 46b. The operative portions of column pairs C and C+1 which reside in octants 18 and 22 are not replaced but are accessed by the main decoders. Hence, spare columns 48 may be eliminated.

10 In the alternate redundancy system, the main decoders cannot be totally disabled during substitution because the non-defective portions of column pairs C and C+1 in octants 18 and 22 must be able to be accessed. An accessing scheme which permits use of this alternate  
15 redundancy system is shown in Figure 11, to which reference is now made.

In Figure 11, the memory array is shown in simplified form as having a left sector or array L associated with a plurality of main memory columns 184 and two spare columns 186. A right sector or array R  
20 is associated with main memory columns 188 and two spare columns 190. Each of the columns 184 may be thought of as a portion or extension of one of the main columns 188. In other words, each main column may have a left  
25 portion 188, each such portion containing half the memory cells of a full column. The spare columns 186 and 190 together contain the same number of memory cells as spare columns 46 in Figure 10.

Also included are main I/O busses 192 and 194 for communicating with the main columns in the left and  
30 right arrays, respectively, and spare I/O busses 196 and 198 for communicating with the spare columns 186 and 190, respectively.

To couple the I/O busses to a data output lead  
35 200, a pair of logic operated switches 202 and 204 are included along with switch contacts 206, 208, 210 and

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212, 214 and 216. The switch contacts are coupled to the various I/O busses as shown, and the switches 202 and 204 are coupled via sense amplifiers 218 and 220 and another logic operated switch 222 to an output latch 224.

Assuming now that a defect D1 renders column pairs C and C+1 in the right array inoperative, the column pair C may be replaced by spare columns 186 and the column pair C+1 may be replaced by spare columns 190.

For example, if the column pair C+1 is addressed, data is retrieved from the operative main columns as well as from the spare columns by the switch 204 closing with the contact 216 for accessing the spare I/O buss 198, and by the switch 202 closing with contact 208 for accessing the main I/O buss 192. The data thus retrieved is coupled via the sense amplifiers 218 and 220 to the switch 222 which may be logic-operated to couple the data retrieved from the spare column 190 to the output latch 224.

When the column pair C is addressed, the switch 202 is closed with contact 206 to access the spare I/O buss 196 and switch 204 is closed with contact 214 to access the main I/O buss 194.

When no spares are selected, the switch 202 may close with the contact 208 for accessing the main I/O buss 192 and the switch 204 may close to contact 214. Thus, various combinations of switch contacts causes various main and spare columns to be accessed, all without disabling the RAM's main column decoders and yet eliminating half of the spare memory cells.

In view of the foregoing description, it can be seen that the present redundancy scheme is adapted to repair large as well as small defects which occur in the main memory cells, and is particularly well suited for repairing defects which cross an address boundary.

0 180 212

Moreover, little or no standby power is dissipated by the redundancy circuitry, and the memory's access time is not substantially impaired.

5        Although the invention has been described in terms of a preferred embodiment, it will be obvious to those skilled in the art that many alterations and modifications may be made thereto without departing from the invention. Accordingly, all such alterations and modifications are deemed to be within the spirit  
10       and scope of the invention as defined by the appended claims.

CLAIMS:

1. A RAM having columns of main memory cells (184,188) a  
plurality of spare memory cells (186,190), a main decoder (36)  
5 for accessing the main memory cells, and a spare decoder (60)  
for accessing the spare memory cells, and a redundancy scheme  
for replacing defective main cells with spare cells,  
characterised in that the redundancy scheme is arranged to  
replace defective main cells with spare cells without disabling  
10 the main decoder, and in that said RAM comprises
- a memory array divided into first and second sectors, (L,R),  
the first sector (L) containing a portion (184) of each main  
memory column and one or more spare columns (186), and the  
15 second sector (R) containing the remaining portion (188) of  
each main memory column and one or more spare columns (190),  
means (192,194,196,198) for accessing the main memory columns  
and the spare memory columns such that, when a portion 9184)  
of an addressed main column in said first sector (L) is  
20 defective and its remaining portion (188) in said second  
sector (R) is not defective, the non-defective portion (188)  
of said addressed column is accessed and a spare replacement  
column (186,190) in one of said sectors (L,R) is accessed in  
place of the defective portion of the addressed column; and  
25 means (218,220,222) for coupling the data associated with the  
accessed portion of the addressed column and the replacement  
spare column to a data output.
2. A RAM as claimed in Claim 1, wherein said accessing means  
30 includes
- a first main input/output buss (192) for accessing the main  
memory column portions in the first memory sector (L),  
a first spare input/output buss (196) for accessing the spare  
memory columns (186) in the first memory sector (L),

a second main input/output buss (194) for accessing the main memory column portions in the second memory sector (R),  
a second spare input/output buss (198) for accessing the spare memory columns (190) in the second memory sector (R),  
5 first logic-operated switch means (204) for selectively coupling to the main input/output buss (194) which accesses the non-defective portion of the addressed main column;  
second logic-operated switch means (202) for selectively coupling to the spare input/output buss (196) which accesses  
10 the replacement spare column; and means (218,220,222) for coupling said first and second switch means (202,204) to the data output so as to retrieve the data accessed by the I/O busses to which said first and second switch means are coupled.



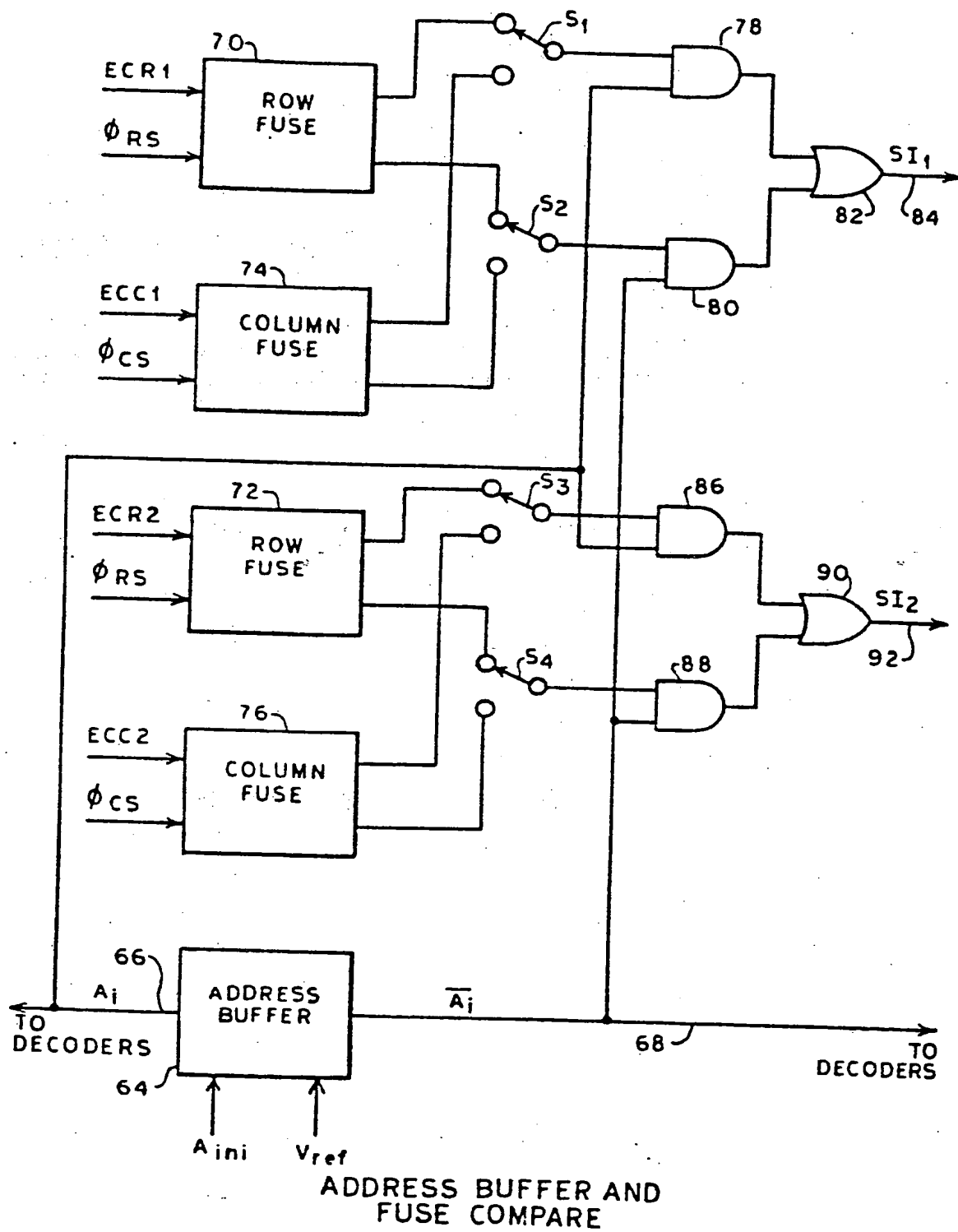


FIG. 2



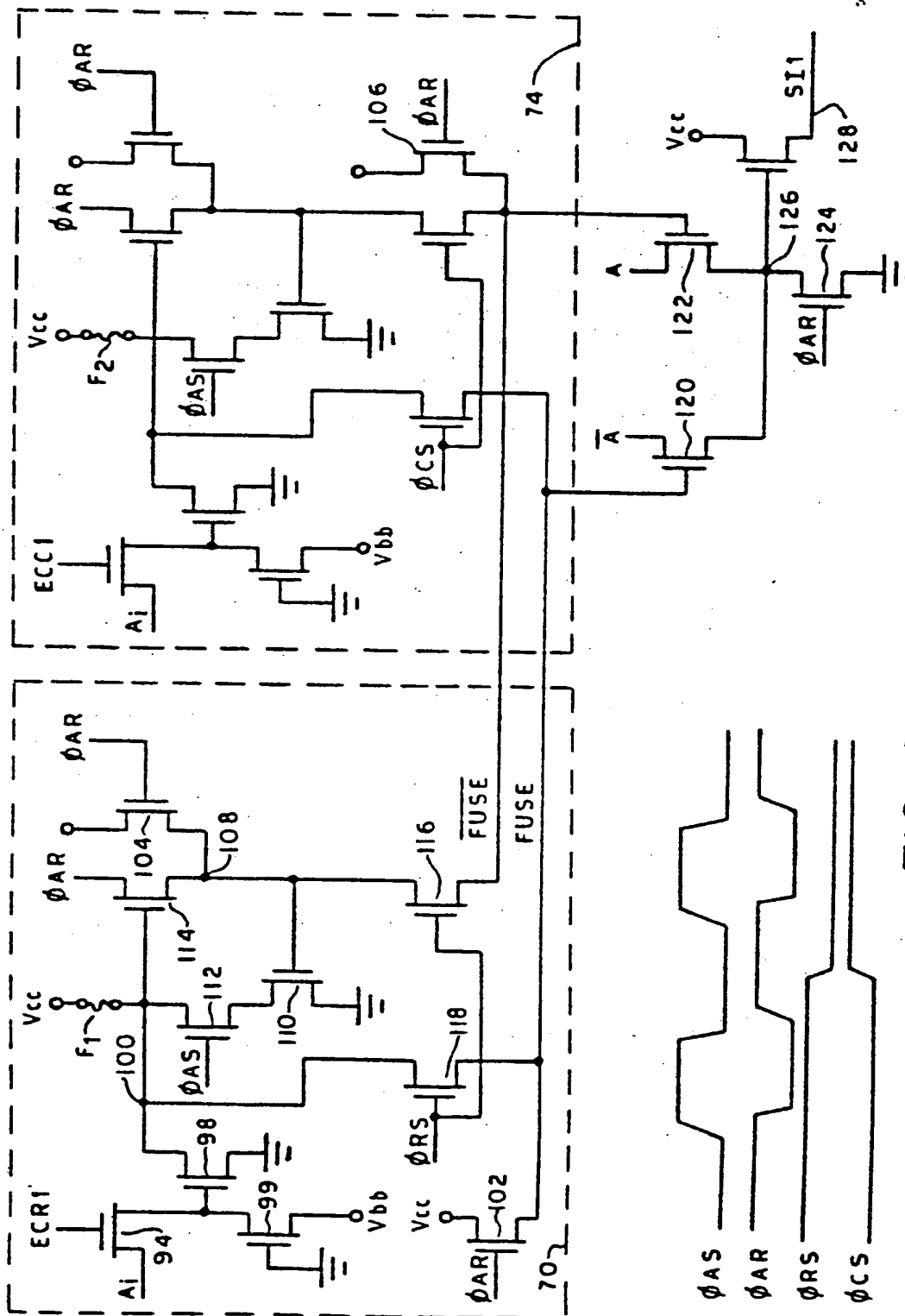


FIG. 3

FIG. 4

